Towards Hard Real–Time Erlang

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Outline

1. Motivations
2. Scheduling in Erlang
3. HARTE: A proposal for RT Erlang
4. Tests
5. Open Issues

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HRT systems: what since now ?

- Hard Real–Time (HRT) constraints are common in many application fields, such as:
  - Control systems (locomotion, security....)
  - Manifacturing
  - Signal processing
  - Telecom
- HRT application are often been developed using C, C++, Ada on top of RT operating systems
- Other “main–stream” languages, such as Java, approached the problem of RT only recently
- Nowadays, RT systems are quickly moving towards embedded architectures and solutions

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Functional programming for HRT: Erlang ?

- Functional programming paradigm can help a lot in modeling, defining, developing, testing and maintaining RT systems
- In particular, Erlang/OTP has been successfully used for massively concurrent soft real–time systems
- Erlang/OTP gives some basic functionalities that are really useful in developing RT systems:
  - A huge and complete standard library
  - OTP, which gives a lot of power and flexibility to manage large systems with a lot of cooperating processes even in distributed environments
  - The possibility of building and deploy embedded Erlang applications in an easy and reliable way
- We think that Erlang has much to say even in the field of HRT systems, but it lacks native HRT support!

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The Actual Emulator Scheduler.....

- The Erlang scheduler does not have support for HRT tasks.
- It is a Multi–Queue Round–Robin scheduler
- There are basically three documented levels of priority for processes: low, normal and high. A fourth priority level (max) is undocumented and reserved for a couple of system processes.
- All user Erlang processes usually run with normal priority, and usage of different priority levels (expecially of high) is highly discouraged
- So the Erlang native scheduler cannot guarantee HRT:
  - No deadline specification for processes
  - No guarantees that a process would finally be scheduled (starvation problems arise using high and normal prio with strange spawning patterns.....)

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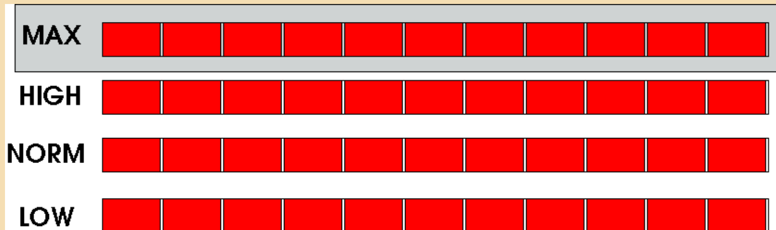
Scheduler Queues



Towards RT Erlang processes

In order to have HRT capabilities in Erlang, three different approaches are possible:

- Writing from scratch a new scheduler for the emulator
  Unfeasible: the scheduler is really entangled with much of the system Existing Erlang code should continue to work anyway
- Modifying the existing MQRR scheduler to support realtime
  Hard: a lot of C code to guarantee HRT
- Adding HRT as a service, which is an erlang application which provides HRT capabilities. This is what this paper is all about :-)

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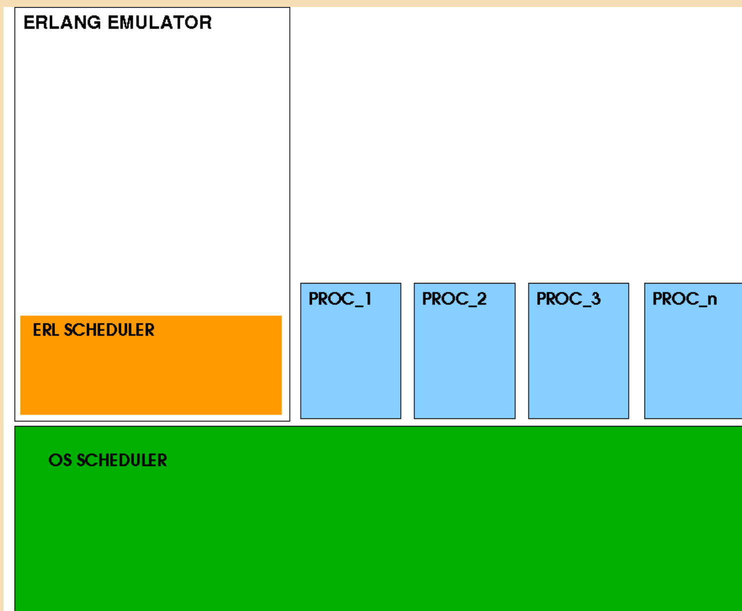
PROC_2
PROC_3
PROC_n
OS SCHEDULER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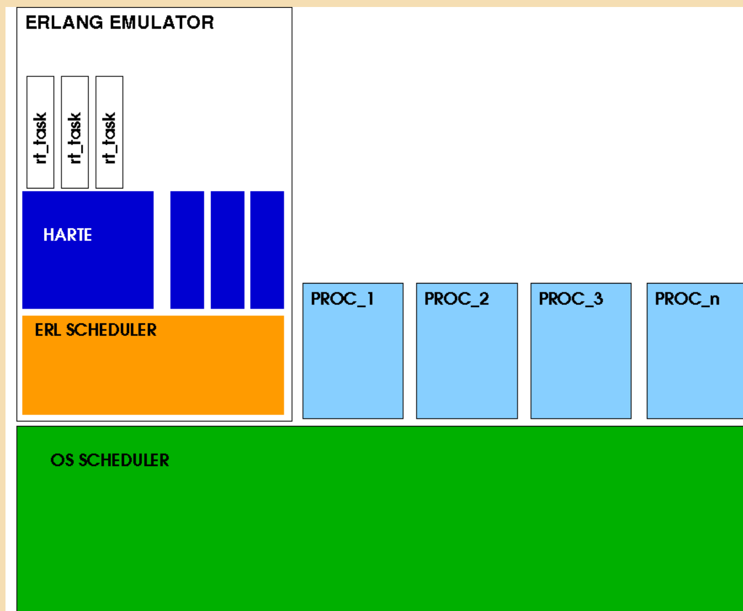
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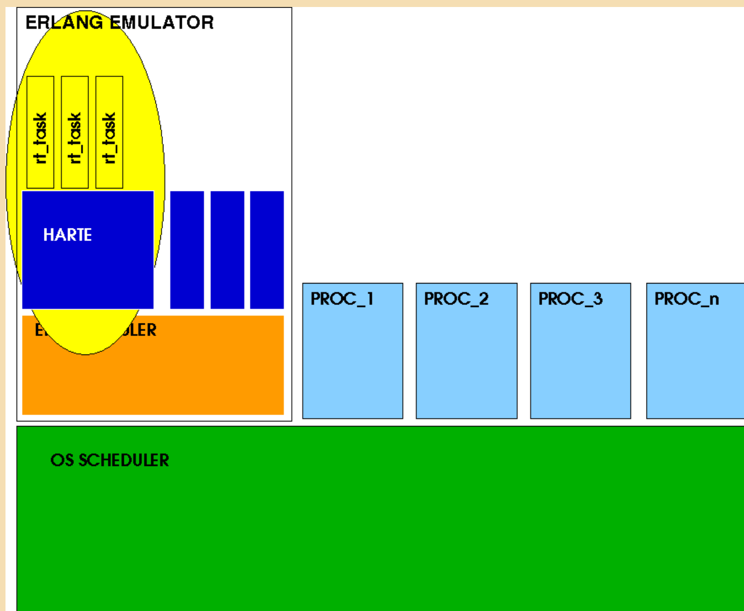
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HARTE: an overview

- HARTE is basically an application (a peculiar one), which is in charge of scheduling RT task
- In order to guarantee RT scheduling of task, HARTE itself runs with MAX priority (*)
- All HARTE tasks (i.e. HRT tasks the user would run), are created as low priority tasks and put in a scheduling queue using a Deadline Monotonic (DM) scheduling algorithm
- Then the scheduler is started and it schedules tasks one by one, modifying the priority of the task to be run to HIGH (*)

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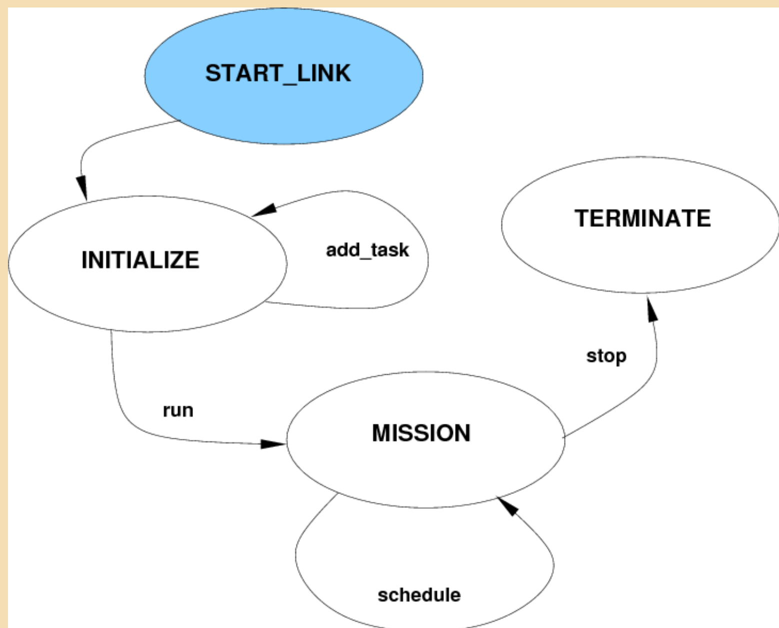
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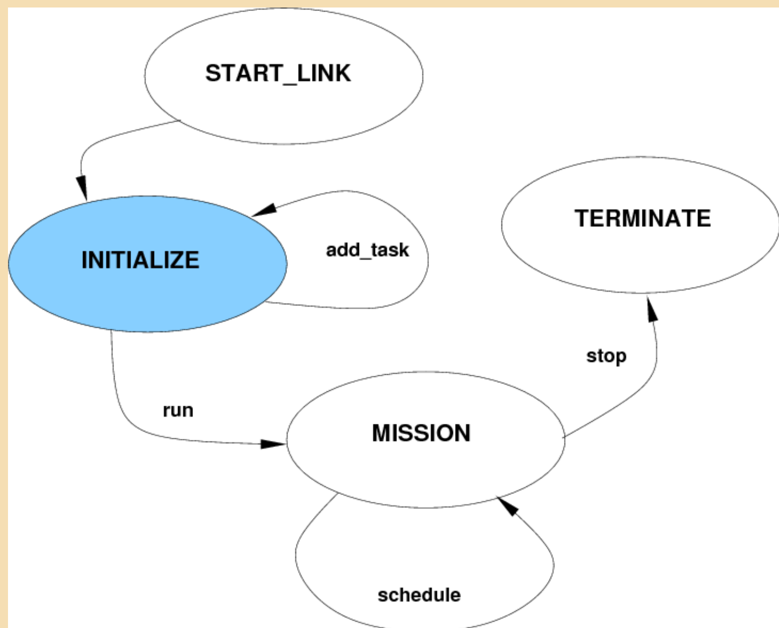
add_task
TERMINATE
stop
run
MISSION
schedule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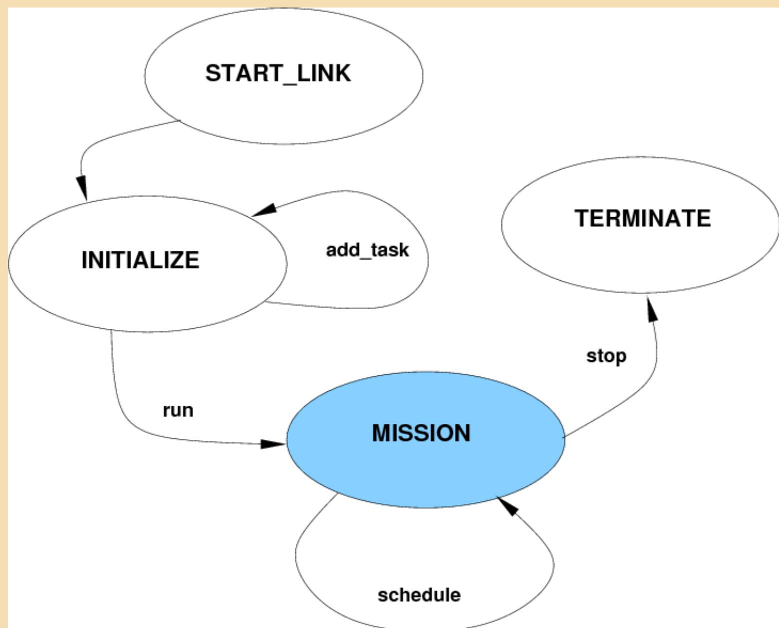
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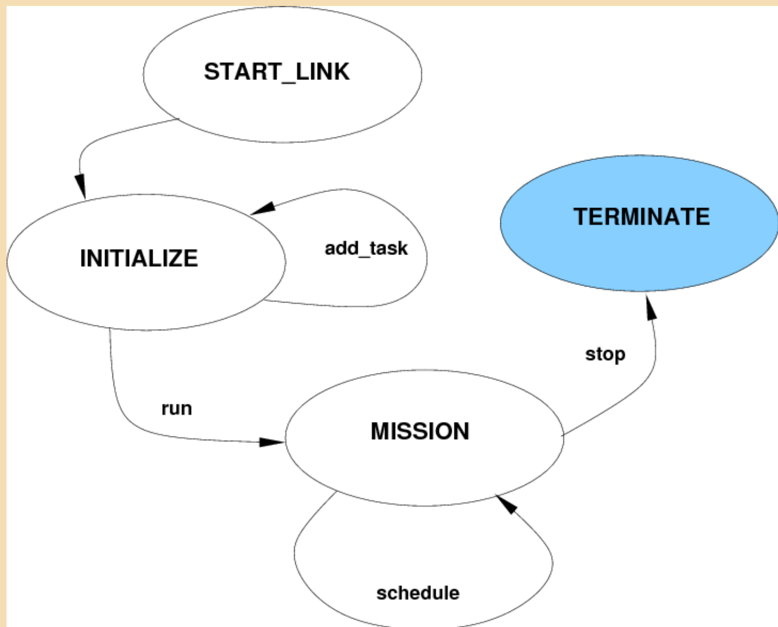
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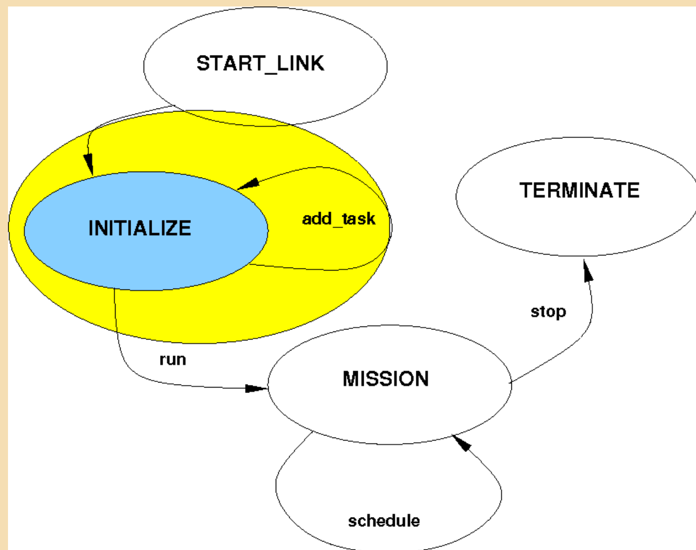
Details: init



Initialisation

- A new behaviour called rt_fsm has been defined. It is basically a gen_fsm with some additional code for RT management
- Each HRT task is represented by an rt_fsm
- In the initialisation phase, all RT tasks are defined and added to the scheduler
- To add a task to the scheduler, the init function of rt_fsm calls rt_scheduler:add_task(),

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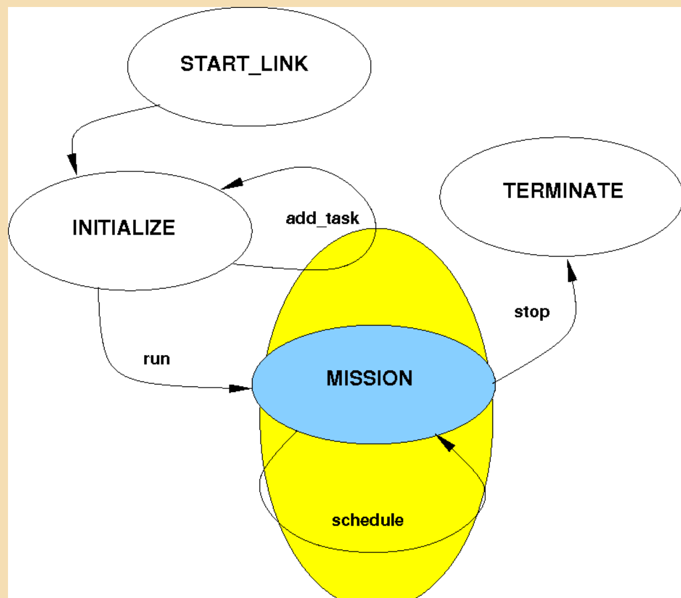

Mission

- HARTE scheduler is started by calling rt_scheduler:run()
- From there on task to be run are picked up from the queue and scheduled.
- To schedule a task, we modify its priority from low to high
- In order to do that, the BIF process_flag/3, in order to let a process change the priority of another process to a level not higher than his own priority level
- Note: This trick is really dangerous, and can lead to weird situations, if misused......or even if used... :-)

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- We tested it with a couple of heavy CPU–bound benchmark, running both HARTE tasks and normal erlang processes at the same time
- The scheduler overhead, in different configurations, is reported in table:

Test	**Average Overhead (μs)**	**Std. dev.**
RT tasks only	13.1	245.78
RT and Non–RT tasks	11.7	52.5
RT tasks many periods	17.9	132.05

Figure: Average and standard deviation of scheduler overheads

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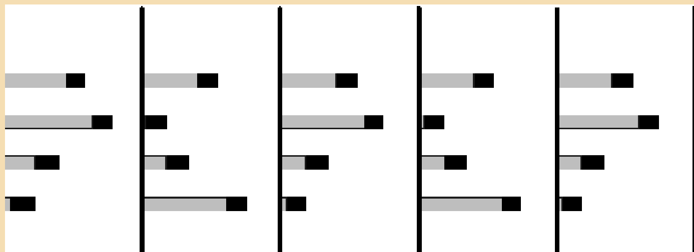
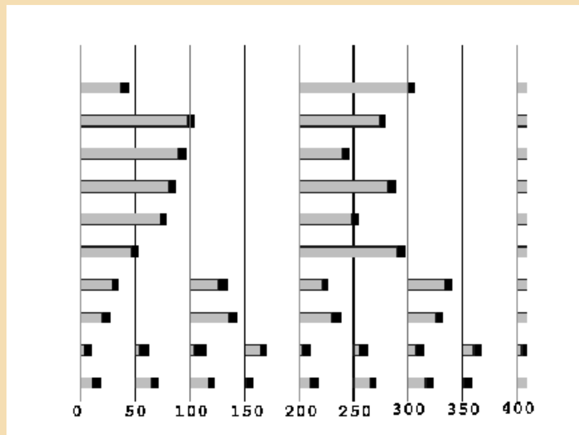


Test 2: RT tasks and 50 normal erlang processes

Test 3: HRT tasks with different periods



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- Support for real–time message passing has to be introduced (a preliminary solution exists!)
- An EDF scheduling policy should be adopted and becomes cumpolsory when you have RT message passing
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